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ABSTRACT

Elementary teachers' attitudes towards science and their confidence to teach it have for some time been identified as important in determining both the quality and quantity of science taught to children. Attitudes and confidence are influenced greatly by the teachers' own experiences as learners of science and as teachers of science. This paper reports on a longitudinal case study of three elementary teachers during their transition from preservice to inservice teaching. The study identifies experiences that were helpful in overcoming initial lack of confidence in studying science and experiences that were perceived by participants to be helpful in preparation for teaching science in the elementary school. The paper identifies ways in which the beginning teachers perceived and addressed constraints to science teaching in the elementary school and how they changed and adapted the knowledge and skills developed at university to practical situations. The use by researchers of a specialist science teacher's perspective for evaluating elementary science classes is discussed. (Contains 47 references.) (Author/NB)

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LEARNING AND TEACHING ELEMENTARY SCIENCE IN THE TRANSITION FROM PRESERVICE TO INSERVICE TEACHING.

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LEARNING AND TEACHING ELEMENTARY SCIENCE IN THE TRANSITION FROM PRESERVICE TO INSERVICE TEACHING.

ABSTRACT

Elementary teachers' attitudes towards science and their confidence to teach it, have for some time been identified as important in determining both the quality and quantity of science taught to children (Schoenberger & Russell, 1986). Attitudes and confidence are influenced greatly by the teachers' own experiences as learners of science (Palmer, 1995; Young & Kellogg, 1993) and as teachers of science (Schoenberger & Russell, 1986; Scott, 1989). This paper reports on a longitudinal case study of three elementary teachers during their transition from preservice to inservice teaching. The study identifies experiences that were helpful in overcoming initial lack of confidence in studying science and experiences that were perceived by participants to be helpful in preparation for teaching science in the elementary school. The paper identifies the ways in which the beginning teachers perceived and dealt with constraints to science teaching in the elementary school and how they changed and adapted the knowledge and skills developed at university in a practical situation. The use by researchers of a specialist science teacher's perspective for evaluating elementary science classes is discussed.

Introduction

This paper examines the professional experiences of three elementary teachers, Jean, Ruth and Katie, and a teacher educator, Judith, over a four-year period. The teachers were enrolled in a three-year Bachelor of Teaching degree at an Australian university. During the second year of this degree preservice teachers studied two units of science education, one in each semester. At the end of each of these semesters they completed a four-week field experience in an assigned elementary school where they taught science. In the final year of the degree there were no science subjects but science units were taught to children by preservice teachers in the field experience blocks at the end of each semester. A group of five mature age preservice teachers were approached at the beginning of their second year at university in 1993 and asked to participate in the study. The study was continued into the final preservice year and after graduation when the participants were employed in elementary schools. Three of the five mature-age preservice teachers who had taken part in the study during 1993 and 1994 completed their university degree at the end of 1994. Two, Ruth and Jean, were available to continue with the study in 1995. A younger preservice teacher, Katie, who had shown a keen interest in elementary science was asked to join the study at the end of 1994. The first author, Judith, was a teacher educator interested in understanding the lived experience of elementary teachers so that she could better facilitate the teaching of elementary science.

Perspectives

For many years research has indicated that elementary school teachers encounter difficulties with science and science teaching in both the preservice and inservice situations. Large numbers of students entering preservice courses for elementary teachers have very little science background (Fensham, Navaratnam, Jones & West, 1991) and are anxious about studying science themselves and teaching it to children. A number of school-based constraints prevent field experience from assisting preservice teachers to teach science in a way that will help to increase their confidence (Appleton, 1984; Henderson, 1992). Large numbers of practicing elementary teachers do not teach science and those who do use teacher led discussion, explanation, demonstration or television rather than investigation in their classrooms (Yates & Goodrum, 1990). Teachers claim that they lack the time and knowledge to organise activities and resources for science (Scott, 1989) and that they have had negative experiences with group work and classroom management when teaching science (Goodrum, Cousins & Kinnear, 1992). Recently there has been a shift in emphasis away from a deficiency model concerned with teachers' shortcomings towards a sensitivity for the teachers' situation and the need to help teachers in their professional growth (Appleton, 1993). It has been suggested that teachers' knowledge and skills be seen in a constructivist light and treated as the base from which developmental changes are made, rather than as deficient and in need of remedy (Louden & Wallace, 1990). During this study we have attempted to take a constructivist view of our own knowledge and skills and those of participating teachers.

The negotiation of change emerged as an important issue at each phase of the participants' development as teachers of elementary science. An anthropological framework suggested by Aikenhead (1996) was used to interpret the experiences of these beginning teachers during their development. The participants' lived experiences in science classrooms at high school and university, are considered in terms of crossing cultural borders, from the sub-cultures of their peers and family into the sub-culture of science. Similarly, lived experiences of learning to teach elementary science are presented as border crossings from the sub-culture of the university into the sub-culture of generalist teaching while simultaneously negotiating border crossings into the sub-culture of the science classroom. The

anthropological framework allows the diverse experiences of individual participants to be explored and compared. The degree of congruence or overlap between participants' existing subcultures and the sub-culture they are required to enter determines the ease with which the change can be negotiated. Difficulties encountered may be conceptualised as hazards to border crossing. Cobern & Aikenhead (1998) categorise border crossings as *smooth, managed, hazardous and virtually or almost impossible* depending on the degree of difficulty with which a crossing into a new subculture is accomplished. Motivations to change can be interpreted as investments in the game (Bourdieu, 1990) that encourage continued attempts at border crossing. Once change is viewed in cultural terms, alternative ways to assist learners or beginners can be envisaged, ways that value the existing knowledge so that it is not portrayed as deficient. We found that we were better able to value the participants' existing knowledge once we came to realise that we were members of a science specialist subculture and as such needed to find ways to cross the border between this subculture and that of the generalist teacher, rather than simply expecting the generalist teacher to attempt the reverse crossing into our subculture.

Crossing borders does not necessarily mean that new cultures are adopted and existing cultures abandoned. Aikenhead (1996) describes instances in which science learning can be considered as true cross-cultural learning. This learning allows knowledge, skills and values of a new sub-culture to be potentially accessible without the need for the beginner to be fully assimilated, that is to put aside current understandings and methods of operating, described by Bourdieu (1990) as the existing *habitus*, in favour of the new alternatives. Aikenhead uses the terms, *Autonomous acculturation* and *anthropological learning*. Autonomous acculturation is a process of intercultural borrowing or adaptation of attractive content or aspects of another culture which are incorporated into one's everyday culture. Anthropological learning, allows that conceptual proliferation can take the place of conceptual modification. He says that whatever option is taken cultural transitions are endemic to cross-cultural learning and that teachers and students need to become what Giroux (1992) termed, cultural border crossers.

Methods

Qualitative research methods were used in this study in order to make sense of the complex world of teaching and teacher education. The data were collected by the first author who worked with practitioners in an attempt to better understand practice and enhance its ongoing practicality (Connelly & Clandinin, 1986) and drew on her own experiences, knowledge and theoretical dispositions, to collect data and present her understanding to others (Glesne and Peshkin, 1992). The particular interpretative paradigm adopted in this study is constructivist-interpretative with case study as its orchestrating perspective. The study consisted of two phases, a preservice phase and an inservice phase. A variety of data sources were used in the preservice phase of the study, including journals, audio tapes of interviews and a science background information questionnaire. The preservice teachers were required as part of their subject assessment in the first science education unit to keep a reflective journal to document their progress as science students during the first semester 1993. Unstructured interviews were held with each of the participants on five occasions during this phase of the study. Participants were asked to discuss topics of importance to them as learners of science. The interviews took place during first semester and at the beginning of the next semester after their initial science teaching experience in schools. Semi-structured interviews were held at the end of final year of the Bachelor of Teaching in 1994 to document experiences of elementary science teaching that occurred later in the preservice phase of the study. During the inservice phase of the study, participants kept written journals during school terms one and two of 1995. Unstructured interviews were held after the first six months of teaching. Classroom observations followed by interviews occurred in the second half of the initial year of employment. A final interview was held at the end of the second year of employment. Audio-tape was used to record classroom interactions and the subsequent interviews. Field-notes were taken by the first author. A process of analytic induction described by Erickson (1986) was used to analyse data from observational notes and interview transcripts. Data sources were read and events, episodes and transactions marked when they represent instances of phenomena of interest. Open coding (Strauss & Corbin, 1990) was used in developing categories into which data could be organised. Analysis was ongoing so that initial interpretations were shared with the participating teachers and altered if necessary. A reflective hermeneutic cycle of writing, thinking and discussion resulted in the presentation of the lived experiences of the participants as multiple border crossings between sub-cultures.

Border Crossing into the Science Sub-culture

The participants in this study all perceived that their high school experiences as science students had alienated them from the science sub-culture. As Appleyard (1992) suggested, even though they were all from Western cultural backgrounds, attempts to enculture them into the science world had caused anti-science feelings. In terms of Aikenhead's theoretical framework they had attempted to cross the border between the sub-culture of their life-worlds and the sub-culture of science on previous occasions and had found the crossing hazardous. Each had been subjected to acts of symbolic violence which resulted in a habitus not attuned to the game of science.

High school experience of science

Ruth began high school with the idea that science would be difficult and her first science class increased her anxiety. She remembered the laboratory as a strange place, full of unfamiliar things and the teacher, who introduced the subject with a demonstration, seemed to assume that students had prior knowledge.

> I remember walking into the lab. in grade eight and I just thought, "What's all this". I found it interesting, I loved the experiments and things, but, they weren't explained properly. ...You sort of get this negative feeling about it. You think, "It's not for me, it's too hard"....it was just the results of things and if you don't understand them how do you know the results. Do you know what I'm saying? It was just really smart, intelligent people do science! Normal people don't.
>
> (Ruth, Interview, 22. 2. 93)

During the year that followed, the teacher seemed to rush through the work and Ruth was left behind. She did not study science after Year 8 and left high-school at the end of Year 10.

Both Katie and Jean described their study of general science from Years 8 to 10 as enjoyable. When science was offered as individual disciplines in Year 11, their alienation began. Jean chose biology but soon felt excluded from this science subject on the grounds of her own lack of ability. She perceived that her teacher was impatient with those who found science difficult. During one of her first biology lessons she was punished, by being excluded from the class. This led her to withdraw from science both emotionally and intellectually to avoid further humiliation.

> He asked what was the opposite of peristalsis and I had never heard of the term before. Because I had no idea and could not answer, I was just told to get out of the classroom and I was up in the library for the rest of the week in science period someone was sent up to check that I was there.... ...I ended up giving up because he made it obvious too that no matter what you tried to do, unless you had it perfect you were not going to be any good so there was not much sense trying because he was going to humiliate you anyway...
>
> (Jean, Interview, 22. 2. 93)

During Years 11 and 12, Katie came to believe that her marks in her chosen science, chemistry were not good enough and that she did not belong with the science students. She perceived that her family, teachers and fellow pupils placed great store on success in science studies. Fearing failure, she put most of her effort into other subjects where she believed she could excel.

> I chose chemistry and maths 1 in my senior years, however they soon became my least favourite subjects. Success at high school was gauged by ones ability to obtain high achievements in maths 1, maths 2, physics, chemistry and biology. This was reflected by family, teachers and peers alike and as I was only an average maths and science student I felt I did not fit into the "Einstein" mould. I felt inferior as a result of not being able to achieve well at these subjects and this is the basis of my dislike in this field.
>
> (Katie, Journal, 9. 2. 93)...

Perceived difficulty of science seems for all participants to be a major border hazard. Their intellectual capital appears to have been rejected and they experienced the symbolic violence of realised failure (Tobin, 1998). If the realisation of failure is the hazard that results in the experience of symbolic violence, the roots or causes of it differ. For one participant the culture of peers and home was too different for her to participate in science even at early years at high school. For the others, the separate-discipline science subjects offered in Years 11 and 12 can be seen as taking students to more demanding boarder crossings than they had experienced in the multi-disciplinary science subjects of earlier years. Students who had had smooth or managed crossings in the early years of high school science now encountered hazards and crossed with difficulty if at all.

Science at university

Katie, Jean and Ruth expected that the science education subjects at university might be more to their liking than high school science but they brought with them habitus resulting from past border crossing. Their new attempts at border crossing into the world of science frequently attested to the active presence of the whole past (Bourdieu, 1990). Participants both re-experienced past hazards and anticipated them unnecessarily. A good example of this is the use of scientific language. Jean described "freezing up" when new words were used but also said that on occasions she went looking for more difficult or obscure meanings than were intended.

> I think "What are they talking about" and I panic more. But when we were going through the process skills, that terminology, process skills, and I was thinking "There has got to be, that sounds really good, there's got to be a lot to this". And, it took a couple of weeks and then I realised it was just observation and writing. Just the simple things.
>
> (Jean, Interview, 15. 3. 93)

Another example of the reinvention of past hazards is the expectation on the part of participants of their own inadequacy as learners of science. Katie, who had had the longest experience of science, was particularly prone to value "correct answers" and rote learning. For example, she was concerned that she could not remember much of her school chemistry and saw this as a result of her dislike of the subject. She worried about not being able to "copy down answers" during the showing of a filmstrip and was reluctant to interact with display materials in interactive work-

stations while we were studying light. In fact the one draw back to the work station approach, from Katie's perspective as a future teacher, was that children might touch the displays. Her tendency to see herself as outside a vast body of knowledge rather than as a generator of this knowledge is well illustrated by her inability to question the apparent results of the activities on electric circuits. When bulbs failed to light, she and her group did not check for faulty bulbs but assumed their ideas about current were incorrect.

> When our group predicted what we thought would happen when certain switches were closed, we found out we were wrong in some cases when we tested them out. This changed my views on electricity and caused confusion as I immediately thought I was wrong. I did not stop to think that perhaps the equipment was faulty
>
> (Katie, Journal, 28. 4. 93)

Managing border crossings

One of the most important aims of science education subjects at university was to assist preservice teachers to increase their confidence in their own knowledge of science and their ability to teach science at elementary level. Judith attempted while teaching these subjects to provide a learner-sensitive environment in which students were encouraged and supported rather than corrected or criticised. Co-operative learning was emphasised rather than competition and Judith had reduced the amount of content so that new ideas could be introduced gradually. During the course of university study some border crossings were successfully managed. The participants were motivated to find ways to do this and not to "give up" because they wanted to teach science to children in elementary schools. In terms of Aikenhead's (1996) image they knew that they were potential tour guides and valued science experiences in their preservice courses that were relevant to the elementary school. They were able to understand concepts when they had hands-on activities that allowed them to "find out for themselves". Hands-on work also slowed the pace of a class and gave time for thinking about new ideas. Participants appreciated having their ideas valued as starting points for learning and not condemned as being "wrong".

Jean had resolved in her journal, never to treat her pupils in the way she had been treated and to find ways of encouraging them even when they gave answers that she as the teacher was not expecting. She commented on the importance of having her responses to questions in class accepted and respected.

> I think it's because we know you now and you're not going to turn around and say "You're mad, you're wrong". Like you said you're there to make it so that nobody is wrong so I don't think it made anybody feel bad.
>
> (Jean, Interview, 22. 2. 93)

A constructivist learning sequence at the end of semester was particularly helpful for Ruth. She liked working out what was happening and describing it in her own words rather than in the terms of an accepted theory. She felt that she was on a more even footing with other students who had a better science background.

> Like you said "Just do it like as though you know no information," which I didn't, it's the perfect way to learn I think..... It's perfect in the way you're doing it because the people who don't know, like me, it's giving us a chance to, you know, go through it and everything. ... I couldn't do it if we didn't sort of do it like that, slowly and letting us work like this, and always rushed and that.
>
> (Ruth, Interview, 4.5. 93)

For Ruth the pace of presentation was important and was linked to the provision of time and space to actually carry out the science activities and discuss what had happened.

> I think it's better now because you're getting into and doing it slow like you said and explaining things and then they observe and why does that happen, why is this growing, why? why? Its all the whys isn't it. I think its better whereas in high school it was terrible. I hated science.
>
> (Ruth, Interview, 22. 2. 93)

Although Katie had not been happy about her ability in science and believed it to be a reason for her rejection of the world of science, she drew on her science background at university. Co-operative learning suited her better than the competitive style of high school science, as did the university emphasis on hands-on experience rather than lecturing. The change in learning environment seems to have assisted her to view her high school experience and her family's interest in science as entries into science rather than the closed doors they had previously been.

> Just having people, I suppose, the family, that knows a bit about it. Cause I'd often go home and ask them and then I'd go tell everyone in my group at university.... I suppose cause we had the books then at home too. Having extra books to look at was helpful. I didn't like science at high school. So I sort of was always worried about it at University, ... the group, having the four in the group that we did. Because everyone at one stage knew something that no-one else did so they'd often tell you and you'd think, oh, you remember that. So that was good. Doing, actually doing experiments. Not just hearing about it but doing it.
>
> (Katie, Interview, 1. 12. 94)

Helping others to cross borders

We were interested to find that once in a school setting, each of the participants saw the relevance of providing access to the science sub-culture for their own pupils. Both Ruth and Katie described elementary science as a beginning leading to what was to come in the future. The importance that each of them gave to this beginning helped to explain to us their motivation for continuing to teach science during their first year of employment in spite of the evidence that other teachers in their schools did not.

Ruth was keen to make the children aware of the world of science, to give them a foundation on which to build. She did not view her teaching as complete, rather she used the image of planting a seed, a beginning that would grow with time.

> Well I think its more an awareness myself, cause I think, just to make them aware of different things. Just all the, all the things I taught, you know, put this idea in their head, you're building up on this little idea that you planted, like a seed that you planted in their head and then as they go on, I mean, Grade 1 science, that's sorta more like a leading into things isn't it?
>
> (Ruth, Interview, 14. 12. 95)

Katie acknowledged that elementary schools lacked the facilities for science teaching that were provided in the secondary setting. However, she stressed the importance of familiarity with science as a way of building confidence.

> I think we're trying to get them interested in it for high school. That's what I think anyway. Because um, when they go to high school, science is much more interesting - they've got the room, got all the stuff around you, and if you haven't been used to it, you might find it a little bit frightening or I don't know what to do, I don't know how to do science, type of thing.
>
> (Katie, Interview, 18. 12. 95)

Jean's teaching was also enriched by her own negative experiences of science, her humiliation by the secondary teacher and her tendency to be left out of some group work at university. Her rational for using groups in her own class was not to facilitate co-operative learning but so that all students were able to participate in the hands-on activities and no one was lost or left behind.

> I had the feeling bag and I had different items in it like bread, I had a marble, had a apple, a unifix cube, a large variety of things and while a child's doing that I've got 27 others sitting there and I couldn't by the time 28 people had a turn I would have had some kids doing somersaults in the background they just get bored. So we did that in a small group so that every child got a turn because I felt it was important that every child had a turn at that so each child came up put their hand in, guessed the items and described them like it was crumbly or soft mainly what's in the sourcebook.
>
> (Jean, Interview, 26. 6. 95)

Jean was very careful to value contributions made by individual children to class discussions. In a lesson comparing the needs of garden animals with those of pets a child suggested that ants did not need water. Jean asked her why and the child responded that the ants were too small. Jean allowed the discussion to continue until other children suggested that garden animals could obtain moisture from plants or rain. She affirmed this answer but was careful to say that bowls of water are not put out for ants as they are for pets. In this way she showed that she accepted and understood the first child's comment.

The participants' stories convinced us that for preservice teachers, who have experienced the symbolic violence of hazardous border crossing into the sub-culture of science in the past, managed crossing is possible provided major hazards or obstacles are avoided. The devaluing of the learner's cultural capital or current understanding and willingness to attempt crossing seemed to be a major hazard. A learner sensitive environment and teaching strategies that value the learner's cultural capital are of great importance. It is also evident that attempts at crossing can be too fast for the learner to manage. A slow pace or some degree of learner control of pace is helpful for a managed crossing. The relevance of science to the learner is found to be highly motivational. Becoming preservice teachers altered the peer sub-culture for participants in the study who now have a need to make a crossing into the science sub-culture so that they could assist the crossings of others in the future. The increased motivation can be interpreted as an increased investment (Bourdieu, 1990) that changes the relationship of the preservice teachers to the field of science and gives them a greater interest in playing the game. Experience of hazardous crossings into the science sub-culture alerted the participants of possible obstacles that their own pupils might meet and helped them as teachers to anticipate and avoid such crossing hazards for their pupils.

Border Crossing into the Teaching Sub-culture

The anthropological framework used to explore learning science can equally be applied to learning to teach. The first year of teaching involves not just an extension or modification of beliefs and practices from teacher education but the

development of a new perspective (Kyriacou, 1993). In other words, when beginning teachers enter the world of the school they encounter a new sub-culture and must find ways of managing their border crossings.

Initial hazards

All of the participants in this study experienced a degree of difficulty crossing the border from the sub-culture of the university to the sub-culture of the real school. At the beginning of their first year of employment they described the feeling of overwhelming responsibility. Ruth spoke of her reluctance to have time off when she was ill and the way in which her attitude toward interruptions had changed now she was the class teacher and not a student teacher.

> Its not the same as when you're on prac that's for sure. Its really weird. You know, and you feel for every one of them. Like, with this little girl that got upset when I was away, I was sick and I'm going, oh I feel so guilty, 'cause one of the teachers told me and I thought, oh I shouldn't have stayed home, but I was so sick. ...and when you're on prac too, you think, library, sport, oh great interruptions you know. You don't have to teach most of the day sort of thing. When you're at school, you don't want any interruptions. You want to get on with teaching them the work. And you think, oh another interruption - I can't cope. You know and you just want to get that work done. And some days you just don't get it done, there's too much work to do.
>
> (Ruth, Interview, 21. 7. 95)

Jean experienced the same feeling of having too much to do. She felt unable to bring her own knowledge to bare on the planning of units or their implementation. We were not directly aware of her initial experiences but she discussed them openly during the final interview in 1995 when Judith brought up the subject of "reality shock".

> At the beginning of the year, it was just a matter of, teaching it, coping. You know, cause with a bit of experience now I feel that I can go at the beginning of the year and expand on some of the ideas maybe and bring in some of my own things, but being first term now, I think its just a matter of teaching what had to be taught and getting by and coping and just doing it and seeing it done. ...Not expanding but um, making it more interesting. Having time to think about that because I was trying to cope.
>
> (Jean, Interview, 11. 12. 95)

Katie was faced with the reality of her own lack of experience with children and the fact that field experience had not taught her realistic ways to manage classrooms. She came to her first teaching position with expectations that her class would be on task and well behaved all the time. Her concern about being in control was a major initial difficulty.

> I think I was too, too concerned with being really quiet and being on task all the time every minute of the class time and not giving them a chance to have a break and talk and chat and then get back to it. I used to pull up everybody every second.
>
> (Katie ,Interview, 9. 8. 95)

Katie began to realise that some of the techniques she had used to manage her classes during field experience were not appropriate in her own class.

> But the pracs in a way were just satisfying the prac teacher type of thing and that's all. I mean there was some degree of everything else like controlling and interacting with the kids but for four weeks, you know, it wasn't really long enough to get anywhere but, it was very surface. Like we do surface things to get the kids on your side. Knowing in the long run that if I had a class of my own I could never do this, like give out the lollies or the tickets all the time to get them to listen but you're only there for four weeks so you do things that will last for four weeks. Its a lot longer than four weeks when you're really in a classroom..
>
> (Katie, Interview, 9. 8. 95)

The temptation to take shortcuts during her time as a preservice teacher had proved too great to resist. Thus field experience was not an effective border crossing to the teaching sub-culture and Katie, like the other participants was left to manage her own border crossing during her first year of employment.

For all participants there was a degree of incongruence between existing sub-cultures and habitus and those of the teaching sub-culture. Although students leave preservice training feeling well prepared to teach, the learned content extracted from university courses becomes irrelevant, superficial and even useless in a real classroom (Olson & Osborne, 1991). This may be explained anthropologically by viewing preservice education as education about another culture that, for individuals without actual experience of that culture, lacks personal meaning and is only superficially understood. It seems that preparation in border crossing provided at university is not sufficiently real to eliminate the hazards that are actually encountered in the school setting.

Managing crossings

The two mature-age participants did manage the border crossing with less difficulty than the younger participant. Their existing habitus included their experience as parents and their jobs involved working with young elementary school children. Thus the congruence between the sub-cultures of home, peers and school was fairly high for these participants and their border crossing relatively easily managed. They both found being able to enjoy the children and getting to know the children in their class well, prevented them from experiencing some of the hazards usually associated with beginning teaching.

For Ruth, having her own class provided the flexibility of being able to change activities that did not seem to be working. When her science lesson on classifying animals began to drag and the children showed evidence of losing interest, Ruth stopped and completed it another day. She did not see the children's behaviour as problematic nor was she critical of herself. She was aware that in her own classroom she had the ability to get to know the children well and the freedom to manage as she saw fit without being evaluated.

> Well, the most important things I've learnt is, um, just personally I just think that you've got your own class, so you bring in your own personality with the children, that's number one I think. Maybe its just ... and because you've got your own class, you can just set your own pace and you know, like I want to do all these things but its up to me, I can organise it the way I want it and that's one thing that's really good I think. You know, whether its science or anything else, its really good that I can do it my way. And in that school it was great cause no-one interferes or anything ...so you're left to do what you want. Like the principal basically trusts you to do what you have to do.
>
> (Ruth, Interview, 14. 12. 95)

Jean planned all her teaching well in advance and in some detail. She was initially concerned with getting everything done. Towards the end of the year she acknowledged that she had been inflexible during the early terms and was overly concerned about completing all the planned work. At the end of the year she was starting to find an entry to the new subculture by seeing that teaching should be less worrying and more enjoyable.

> I probably need to be a bit more relaxed and enjoy the children a bit more rather than concentrate on, oh, ... this work, has to be done. You can get by if its not done, you can always catch up later or something. That was just really, I was really aware of that at the beginning of the year. That oh its Monday and this is down for Monday and we must do it today. Come hell or high water.
>
> (Jean, Interview, 11. 12. 95)

Katie seemed to experience the most difficulties in crossing the border between the sub-cultures of university and school. She described how she had to change her view of successful teaching in order to negotiate the hazards of beginning teaching. Her initial measure of success as a teacher was that her class would be on task and quiet at all times. When this was not the case she blamed herself and her lack of experience. With encouragement from more experienced teachers she came to see that her expectation of having complete control was unrealistic and that the children had to "do their own thing sometimes." She realised the importance of knowing individual children so that she could adjust her expectations of them to meet their needs rather than treating all children in the same way as she had at first thought appropriate.

> I suppose it was changing my view of being able to master things. You know I would just, took up, say, the piano. I'd just keep practising till I got it right. When I got the song right I was happy. And so I was thinking if I hadn't got this right, so I'm not doing, I'm just doing something wrong. What am I doing, you know. And then after six months you realise that you're not doing anything wrong, you're just thinking, you're putting too much, sort of, putting too much into it for a start. You know, you're expecting too much of the kids. That they be good all the time.
>
> (Katie, Interview, 9. 8. 95)

Katie's previous experience, exemplified by her description of learning the piano, had not required her to take the needs of others into account when striving for success. In addition, she learned the value of relaxing more and taking some time off instead of putting most of her free time into planning. She described how after a holiday break when she did not do any school related work, she was refreshed and the children seemed calmer.

> I remember my first Easter holiday, I spent the whole week just doing work. And I came back in term two and I was really tired and really cranky. And um, and the next holidays, I didn't do anything and I came back more refreshed. And I sort of did it during the nights for the first week, you know. ...even the difference in the kids when they came back from holidays they were just better behaved you know than they had been you know I was coming to the end of the day and I didn't feel as tired as ragged as I had been they were just a lot easier than they had been.
>
> (Katie, Interview, 9. 8. 95)

When Katie began her career she experienced a lack of congruence between her existing sub-cultural worlds and the world of the real school. The major hazards that impeded her border crossing were her view of successful teaching as having complete control of a quiet class and her belief that success was achieved by putting more effort into a task. Both of these beliefs could probably be traced to her previous experience as a high achieving student and formed part of the habitus she brought to teaching. When her intellectual capital was rejected she experienced the symbolic violence of realised failure (Tobin, 1998). Border crossing was only possible after she re-examined her beliefs about success and achievement.

Findings from this study indicate that the type of border crossing experienced by beginning teachers depends largely on the habitus (past experience and understanding) that they bring to their new occupation. Past experience can be either a help or a hindrance to border crossing. The mature-age teachers, Ruth and Jean, experienced some initial difficulties coming to terms with their overwhelming sense of responsibility. However, their border crossings could be described as managed as their past experience assisted them to avoid hazards. The youngest participant had a hazardous border crossing accomplished only when she began to adopt new beliefs about successful teaching and new beliefs about ways

to achieve success. Her habitus had been the least attuned to the game of teaching and the most in need of adjustment. All participants showed some initial conservative teaching behaviours such as concern with completing work and having quiet classrooms. However, all reported greater enjoyment of teaching and more success when they learned to relax and to have realistic expectations of themselves and the children. Unrealistic expectations emerged as a major hazard for border crossing into the teaching sub-culture. Field experience during preservice teaching can help to achieve realistic expectations of classrooms but two of the participants identified evaluation during practice teaching as deterrent to real border crossing into the world of teaching.

Border Crossing into the School Science Sub-culture

The elementary school teachers in this study found teaching science to be more difficult than teaching other subjects. Thus science classes and "other classes" can be interpreted as different sub-cultures in the school setting. Teachers need to cross borders between these sub-cultures in order to teach science successfully. When the habitus of skills and knowledge that teachers bring to science classes from teaching in other areas are not sufficient for science lessons, teachers experience symbolic violence as they attempt this border crossing. Some teachers find the crossing impossible and do not attempt science teaching.

Border crossing during field experience

Co-operative learning groups and hands-on activities were used during university based science classes and the participants expected to be able to implement such lessons in elementary classrooms. However, field experience was something of a disappointment in this regard. All three participants claimed that they seldom saw science taught by experienced teachers and sometimes did not complete the teaching of prepared science units. All had difficulties with management of science lessons. Supervising teachers did not seem able to support the beginners in developing the skills necessary for using co-operative groups and hands-on activity.

Ruth's first science lesson, during field experience, taught her the importance of allocating children to groups clearly and quickly. She attempted to put children into groups and to simultaneously give them a number in their group to which a task was allocated. The children became so noisy that she stopped the process and began again.

> When I said, "Now split up into your groups, you know your numbers" - complete chaos! Just went completely out of hand. So I thought "Righteo, stop this", you know. I said "STOP !" "SIT DOWN !" "START AGAIN!" I was losing my cool by this you know.
>
> (Ruth, Interview, 4. 4. 93)

In later field placements Ruth did not have a great deal of time to teach science and seemed to teach a range of single, one off, lessons rather than units of work. She did not tell of any other experiences during her field placements in which group work was done.

Jean also was concerned about the behaviour of children in her first field experience class but used methods suggested by a behaviour management expert, who was working with the class at the time, to teach each step of the process of forming and working in groups. She had similar difficulties with the behaviour of the boys in her Year seven class the following year and realised that the boys had had little prior experience with group work.

> The only time they would work in groups was at the lab. table they hadn't been skilled in any group work and it was almost chaos and they were fighting. They did not know how to take turns or to encourage others to participate, one person would take over and things like that. Science is a good thing to do in groups so you need to be able to work in groups and that goes back to the need to skill them in how to work in groups.
>
> (Jean ,Interview, 27. 11. 94)

Katie mentioned difficulties with group work in two of her four field experience classes. On one occasion when she was teaching a Year three class about eggs, her groups were large and she allowed children to work in places where she could not watch them effectively. The children misbehaved and the supervising teacher intervened by stopping group work and putting the class into a large circle to watch teacher demonstrations. Katie was disappointed about the lack of real hands-on activity.

> In the conclusion I took the children outside and sat them in a circle... I discovered that a change of environment and a circular class group does work for control in the science lesson. This however contradicts an important objective of science in the elementary school, "hands-on". I found that as soon as the children were in their groups doing "hands-on" investigating with the egg they were difficult to control and monitor. The noise was exceedingly high and the children were mucking around.
>
> (Katie, Journal, 24. 4. 93)

Katie, Jean and Ruth, found that managing the complexity of a classroom in which children worked with other children in groups while at the same time having access to unusual and interesting materials, presented major difficulties for

them during field experience. The participants realised that the children had had little previous experience of hands-on or group work and that they would have to teach the children new skills. In anthropological terms the teachers were aware that both they and their pupils would have to adjust their respective habitus if science classes were to be successful. Border crossing was essential for both teachers and pupils.

Border crossing in their own classrooms

Although the participants completed their field experience without a great deal of practice of border crossing into the science classroom, they were keen to attempt such crossings in their own classes. They had all experienced the enthusiasm of the children during science lessons and this seemed to be a major motivation to continue with science teaching. The children had shown themselves to be keen travelers and thus encouraged the teachers to see themselves as potential tour guides or travel agents or to maintain their investment in the game of science. However, in this process the teachers seemed to underestimate the hazards they were likely to encounter when crossing borders into science classrooms in the future.

During their first year of employment, Jean and Ruth taught younger children and did not appear to have the same degree of difficulty with science classroom management as Katie. Nevertheless they often used teacher-directed discussion and teacher demonstration. Ruth was reluctant to set up groups in the classroom early in the year. She found that children were less attentive when they worked in groups.

> Well, the first term they were here I had them (the desks) like in a "U" shape, ...And I liked that cause I taught at (field experience school). The Grade one teacher had them like that and I liked it. They seemed to be altogether but yet separate. And then I switched, in second term I switched them and had them in groups. ...And it just didn't work, they were just talking and carrying on like, it just didn't work at all.
>
> (Ruth, Interview, 21. 7. 95)

Even though Ruth did not regularly use group work she claimed that she learned a lot about groups during her first year of teaching. During two lessons I observed she made notes of ways of improving management of groups the following year. A lesson in which groups of children tested string telephones had been noisy and consistent results were not obtained. Ruth thought that allowing one group at a time to do the activity would provide a quieter working environment. The main problem with a "sink and float" lesson was the difference in the amount of time taken at each work-station. Ruth made a note to allow more equipment at some stations with complex activities, so that more than one group could work there at a time. When she saw the children starting to throw objects into water and do other inappropriate things while they were waiting to work at the next station she stopped the activity and issued new instructions.

> First of all, we are not going to drop apples and potatoes from up here or logs. Someone's already spilt water on the carpet. We are going to do it very gently. There's no need to throw them up on the rooftop. Secondly, things have changed. We won't be going around like we said, because as I said, some people are taking longer than others. So what you're going to do is, you're going to look if a station you haven't done is empty. And you're not going to be running around like maniacs. You will just go very quietly. ...So as long as you see somewhere that's empty, you just go and do it.
>
> (Ruth ,Observation, 1. 9. 95)

Jean liked seating her children in groups, but this was a way of making more space in the room rather than a way of fostering co-operative learning. Like Ruth, Jean used whole class activities in science more than group work. A lot of her activities in science were pencil and paper based. She was not really satisfied with this and did not see it as real science. However, her status as new teacher in the Year one team prevented her from voicing her concern. Even with pencil and paper activity Jean had some initial management problems. One of her early lessons in the unit "ourselves" involved the children tracing their partner's hand on a piece of paper and then comparing hand sizes to find out who had the biggest hand. A final task was to see who had the largest hand in the class. Jean tried to manage this last part of the lesson as a whole class activity but the children became bored and very noisy. She modified a subsequent lesson so that it moved more quickly and the children had a variety of things to do.

> One thing I have learned is that these little ones need to be constantly active and changing pace and position and activity to maintain their interest. If interest is maintained control of the class is so much easier, and this makes me as a teacher feel that I have achieved more and enjoyed the children more.
>
> (Jean, Journal, 8. 2. 95)

Katie was also implementing a school-based curriculum, new both to her and to the school itself. The curriculum resource was based on the use of co-operative learning, so groups and manipulatives featured in it. Katie struggled to find ways to organise children into groups, encourage them to co-operate with one another, manage the manipulatives in the classroom and ensure that learning was occurring. She believed that her own lack of experience as a teacher was a major part of the problem as she was unable to anticipate the children's behaviour and unsure of how to manage the classroom generally.

> I just sort of felt that I couldn't do it all at once. I didn't know whether to choose or to concentrate on co-operative learning and really do that or just get the content across as quickly as possible and you know something like that. The teacher last year, until she retired end of last year... was a very old lady. You could tell from day one they were just used to writing and sort of old fashioned type things not, when I wanted to do something different, they didn't know what was happening. Science was a bit different for them altogether, they did love it there wasn't one kid that didn't like science when we did it and I was the only one that shuddered when we did it. (Laughing)
>
> (Katie, Interview, 27 6 95)

Katie persisted with group work for the whole year. She found that, as the term progressed knowledge of children assisted her to organise groups so that they were on task and also took friendships into account. At first Katie had selected groups that seemed to her to keep the most difficult children apart. One of the boys pointed out to her that girls always got to sit with their friends but that boys did not. From Katie's perspective this was because the girls did not allow their differences of opinion to disrupt the class as the boys did. In the next term Katie felt confident enough to change her approach.

> second term I changed my approach altogether. I started to put them with their buddies, not totally, with the group with two of their cronies, but with another one they do get along with really well and use it like that way. And it worked a bit better. But the biggest problem with *Primary Investigations* is the group co-operation
>
> (Katie, Interview, 27 6 95)

Unfortunately, organising groups to ensure acceptable behaviour was easier than getting the group members to work well together during class. Conflicts when children felt that they had been excluded from an activity arose throughout the term.

The management of groups was not the only difficulty the novice science teachers faced during science lessons. Managing equipment was equally challenging. Katie found managing equipment particularly hard because so many of the science lessons involved manipulatives. When the class was making balloon powered cars she commented that, "some children were distracted with the materials. (I had rubber band flicking and paddle pop stick knives for days)". We deduced that this was fairly typical behaviour encountered by teachers, when Katie described the concern expressed by the experienced teachers during an inservice program when they found out what materials were needed for the introductory lesson "liquid layers."

> The other grade six teachers their mouths just about dropped open, "what!" they said "can you imagine coloured water, rubber bands, straws and water in the same room."
>
> (Katie, Interview, 27 6 95)

Katie avoided management problems by doing this lesson as a teacher demonstration. In future lessons she was aware that manipulatives could cause difficulty and tried to restrict their use. On occasions the result of limited materials was increased time when children had little to do. During Judith's first visit to Katie's classroom Katie was teaching a lesson about energy during which the children made a cardboard toy that incorporated a rubber band which could be stretched and released making the toy, the "flic-flac", jump. The children became noisy and argumentative, especially when they had to wait to use equipment or were watching demonstrations. Katie was concerned about allowing children to use scissors to punch holes in the cardboard but there was only one hole-puncher for the entire class. When Judith suggested that it may have been better to pre-punch the cardboard Katie said that she felt the children needed to be kept busy. However, she had restricted the number of "flic-flacs" made by each group to one, in order to reduce the amount of equipment in the room, thus defeating her aim of having all the children busy. Having only one "flic-flac" per group prevented children comparing toys within their own group in order to deduce which had the most energy and necessitated a whole class demonstration of the toys to make this comparison. Children became restless and management was a problem. Katie was torn between allowing the children to participate fully in hands-on activity and keeping materials at a level she felt she could manage.

Successful border crossings were provided by the unit on astronomy. Katie immediately saw the benefit of having, what she termed, "tamer" manipulatives in the room and using teacher demonstration rather than group investigation. She described these lessons as more like maths lessons. The children made individual planispheres out of paper and watched a video about planets.

> This unit looks like its going to be good, just about everyone likes Astronomy and there is not much group work!! (sigh). Most children were able to construct their star maps and every member of the class made one so there was no arguing or the like. I think Astronomy is every teacher's favourite topic in Science, it's definitely mine. There are few messy experiments and it's very fascinating studying the night sky. I suppose it is really "theory" science and there's not much opportunity for "hands-on"
>
> (Katie, Journal, Term 2, 95)

We were struck by the similarities between Katie's description of this unit and the teaching strategies initially favoured by Jean and Ruth. We concluded that some teachers solve the problem of management of manipulatives by simply choosing activities that use "tame" things like pencil and paper or reverting to teacher demonstration.

Katie did find ways to manage science materials effectively toward the end of the year. A successful lesson involving hands-on activity was the one on electricity in which Judith supported Katie by providing equipment that was organised into kits. Katie allowed only half the class to do the activities at a time. She was fairly relaxed about the children's exploratory behaviour on this occasion and allowed them to investigate the conductive properties of a range of things in the classroom as well as those provided in their equipment kits. The smaller number of children made less noise and fewer manipulatives were required to have the children fully involved in the activity. These factors, combined with Katie's changing view of appropriate behaviour for children, gave us the feeling that she was happy with the management of the lesson. Teaching the lesson twice was also an advantage. The first half of the class was reluctant to pause during their investigation and answer questions suggested in the lesson guide. Katie learned from her experience and had the satisfaction of a more smoothly flowing activity the second time by keeping all the questions until the end of the lesson. In this instance teaching to a smaller group of children and using equipment kits, provided a bridge to successful science teaching. We were surprised that Katie had not used these strategies more often as they seemed to be particularly appropriate for beginning teachers.

There is evidence in these findings that the participants needed to make border crossings into two new sub-cultures simultaneously. As discussed previously, the mature age participants Ruth and Jean, found the border crossing into the sub-culture of the school relatively easy to manage, but the youngest participant, Katie, had a much more hazardous passage. All had to negotiate difficult crossing into the sub-culture of the science classroom. It would seem that the mature-aged participants prioritised the crossing into the general teaching sub-culture and delayed, to some extent negotiating the border between the science classroom and other classrooms. The youngest participant attempted both at once, and it is understandable that she was relieved to have a break from hazard negotiation, when she taught the astronomy unit in her curriculum package. Using strategies usually associated with other discipline areas can be interpreted as an example of autonomous acculturation. It can give a beginning teacher time to practice more general teaching skills before attempting to re-encounter the hazardous borders of the investigative science classroom. In addition, teaching strategies from other subjects may, as Roth (1993) suggested be of greater assistance in concept development than some hands-on activities.

Border Crossing between the Sub-culture of the Generalist Teacher and the Sub-culture of the Specialist Teacher

We became aware, during our work with the beginning teachers, that our attempts to interpret classroom events were being made from a perspective different from that of the participants. In fact, the differing perspectives could be interpreted as those belonging to discrete sub-cultures. As a science graduates teaching science, we belonged to the sub-culture of the specialist teacher, while the participants were novice members of the generalist teacher sub-culture. Specialist teachers may be seen as those for whom the sub-cultures of teaching and science are congruent or overlap considerably. On the other hand generalist teachers, who work at the elementary level of education, are those for whom the sub-cultures of teaching and science are often discrete so that the field available for the game of science teaching is different from that available for specialist teachers. The experiences of the participants in this study indicate to us that four teaching conditions, dedicated space, assistance with equipment, high status of science and detailed science knowledge, represent the hazards that inhibit border crossings between the sub-cultures of generalist and the specialist teachers. These four conditions are among the most important features that distinguish the two sub-cultures. The experience of teaching science or learning science when these four teaching conditions are met is not a real preparation for the conditions of the generalist's world. We became aware during the course of this study that, as specialists, we tend think about science teaching assuming that these conditions are givens.

Space for science

Judith noticed that groupings of desks varied in each classroom throughout the time she visited. Eventually each of the teachers found an arrangement that suited their needs. Jean usually clustered the children's desks into groups of six, not as a way of promoting group work, but to give her space for children to sit on the floor for stories or class discussion. Ruth's use of the "U" shaped desk configuration allowed easy classroom management and a central floor space if needed. Katie tried a range of desk arrangements including clusters of six desks. Having desks in a cluster of six facilitated movement into science groups as each cluster contained two groups and it also left a relatively large floor space between groups of desks. The down side was that the six children in each cluster were very close together and able to chatter and to interfere with the work of others. Subsequently the room was rearranged as rows of alternating double and single desks. Katie said this was because the larger groups were getting too noisy, but she regretted that most of the floor of the room was now taken up by desks. During a lesson about the pendulum, when this desk arrangement was in place, it was particularly difficult for children to find room to work where they could swing a pendulum without knocking that of another group. We began to understand that using "tame materials" such as planispheres, not only made children's behaviour easier to manage, but also suited the classrooms where children had to work in close proximity with one another.

Although participants often persevered in cramped classroom conditions, each found effective alternatives that provided space for group work. Ruth was fortunate in that she had easy access to outdoor areas if necessary as her room opened onto the playground on one side and a large covered space between classrooms on the other. She took all the children into the playground during a unit on gravity for example. Jean also used outdoors for some lessons. She took her class outside to explore garden habitats and to discuss the differences between living and nonliving things. Katie found her cramped classroom particularly difficult. One strategy she tried was to split the class in two and have half the children at a time doing science. This was particularly effective in the electricity lesson already described. However, there were some problems with the arrangements Katie had made. One half of the class had been sent to the library with a teacher aide, but found that the teacher librarian was absent. Students were not allowed in the library without a teacher. When Judith suggested allowing that the other half of the class could remain in the classroom room or on the veranda outside and have a different activity, as they did when Katie took reading , Katie was not confident that she could manage.

> I think it'd be too difficult because um, like they want to come in, they want to have a look what they're doing. They just can't stand the fact that they're doing something else and people are doing science or something fun. They don't seem to realise that they're going to be doing it soon anyway. ...Its more trouble that its worth.
>
> (Katie ,Interview, 7. 11. 95)

Science equipment and materials

The participants like teachers described in the research literature (Fraser, Tobin & Lacy, 1988; Jeans & Farnsworth, 1992; Mittlefehldt, 1985; Scott 1989) had difficulty managing and obtaining science equipment. Their schools did have some science equipment but the participants' novice status often meant that they did not know what equipment was available. Initially they found items at home or bought things they needed themselves. At Katie's school, the school-based system of management for science materials, a trolley of equipment for each school building, was in need of revision to suit the new curriculum. Katie had checked the trolley in her building but did not find any of the items she needed for her science lessons. She told about a staff meeting during which plans for managing equipment were discussed. The teachers at this stage had all been using the new curriculum for a full year without an update of the school system for obtaining and managing equipment.

> Well the teacher who's the key teacher for science had a day off last term and she went around and organised the equipment. We were talking about it at a staff meeting and there's a bit of a debate about how we should organise it. There was one suggestion that we have a shed, like a science shed and just put everything in there and then the science teacher, the key teacher, would go and prepare everything for the classes and people were saying "that's too much work" for one person. Why don't we get it ourselves, and then she said, well, you know, teachers never put things back, or keep them in their room. The other suggestion was, something like a cupboard in each room. But then people were saying "but we have something similar to that, like science trolleys", its not for each year level, its just for each building, but some teachers said they had the science trolley in their room and some of the kids were just getting things out of it or people, other teachers were borrowing from it and weren't returning it. Just things like that. So they haven't sort of decided how they're going to organise the equipment....
>
> (Katie, Interview, 18. 12. 95)

The schools in which Jean and Ruth worked had a different system in which one of the upper elementary teachers and her students were in charge of distributing the existing equipment when it was requested. Finding out what resources were available was a problem for both Jean and Ruth. As a new staff member Ruth said that she sometimes "just stumbled" on equipment and resources owned by the school. Jean thought that the having taught the curriculum once would help her with organising equipment in the future. She said that she did not have time to go and look at the equipment as she was so busy with week to week planning, and that she doubted there would be much there anyway.

> (This year) I didn't know what equipment was available in the school. I'm probably still not aware of half the stuff. I think too, somebody said this to me the other day, one of the partner teachers said that next year will be easier because you know what's coming up and you can get your resources ready and that's true.
>
> (Jean, Interview, 14. 10. 95)

The participants usually found of bought their own things for science as a first attempt at obtaining and managing manipulatives. Katie said she felt more confident that everything was available when she had her own set of equipment in her room. She was able to find most things that she needed at home, but she also purchased items, like the washers for the energy games "one-up and all-up," herself. Cost, as well as ability to manage children's behaviour, then became an issue in deciding how many items to allow in the classroom. When Ruth wanted thermometers for a weather unit, none were available, but the school was willing to order them. Like the others, Ruth found many manipulatives she needed for her classes at home and kept materials in her own room for use in future. As the year progressed, she started to ask at school for some of the more ordinary items she would initially have tried to find herself.

> I got the grounds man, I asked him if he could get me a wheelbarrow full of dirt, cause I was going to take it in from home and then I thought, oh blow it, I'm not carting this in. Got to start being smart. So I asked him and he said yeah all right, so he got me a wheelbarrow full of dirt. And

he said to me there's lots of pots under the office. If you open the store down underneath there, and I thought, oh fair enough, cause I was going to take them from home and I found heaps of them.

(Ruth, Interview, 14. 12. 95)

During an interview with Katie, Judith became aware that anticipated difficulty in obtaining equipment could be a reason for avoiding a topic. Katie had been going to avoid this lesson because she thought that bulbs, cells and wire would be too difficult to obtain. When Judith provided kits for this lesson Katie willingly included the lesson and described it as her most successful science lesson that year. As with solutions to the problem of providing adequate space for science lessons, we could see that from our perspective more adequate ways to manage of science materials could be found.

Science knowledge

As an observer in elementary classrooms Judith was most aware of her own feelings of unease when she thought she detected evidence of limitations to children's learning that could be attributed to the participants' inexperience with science concepts. Because she tried not to expect generalist teachers to have the same depth of knowledge as specialist teachers, she was surprised at her tendency to focus on what she perceived to be the participants' difficulties with science concepts during observations in their classrooms. Of the three participants Katie had the greatest experience with science at high school and the best access to resources at home. She had relatively few difficulties with science knowledge but was aware that the children she taught would challenge her if they thought she was unsure of the content of any lesson. She was particularly anxious about this in the early stages of the year when her own feelings of newness and inexperience were overwhelming.

If I don't know the content there's no way I will teach it. I'll not get up in front of thirty kids and have them think that I don't know anything because they're already thinking that, that's what I think, I don't know whether they do think that. I felt they were all just, you know ,they could see right through me like I was that stupid I didn't know anything. . .

(Katie, Interview, 9. 8. 95)

On occasion, Jean's work showed the limitations of a generalist teacher's knowledge when compared with that of a specialist. She did not seem to be aware that searching for animals in the garden during the hot part of the day would not be productive unless she was prepared to dig for worms or turn over stones or wood to find slaters and ants. Her lesson on pets emphasised that shelter was connected with care from humans and that this was most important for animals. In drawing parallels with garden animals she suggested that the appropriate care from humans involved not interfering with the natural habitat or injuring the animal. We were impressed with the way Jean linked the topic of animal needs with an environmental issue, but were also aware that Jean did not seem to understand or explain the role of shelter in providing protection from predators, extremes of temperature or desiccation.

Ruth was left to her own devices in choosing a science program for her class. There did not seem to be a school-based curriculum as in the case of the other participants. She chose investigation as a major aim for the year and often challenged the children to find out what would happen. In some instances Judith thought that Ruth could have extended the discussion of a topic or provided further clarification. For example, Ruth chose a series of lessons on gravity which the children really enjoyed. She prepared by reading the teachers' resource and the children's activities. It became evident during the lesson that Ruth did not see the significance of the Earth's centre in the concept of gravity.

Ruth	What made it stop from falling this time? What made it stop from falling? It could have gone.. how far down could it have went? If there was nothing to stop it from falling? Sam?
Child	Right to the centre of the Earth.
Ruth	Oh it could have gone on and on and on. Couldn't it? So what made it stop from falling this time? Samantha?
Child	The carpet.
Ruth	The carpet, or the floor. Didn't it? There was still something there to make it stop. But it still went down. Didn't it? OK. Now. If I had a big hole in the floor like I just said before, and these children dropped it and there was nothing to stop it. How far down could it go?
Child	Right through the Earth.
Ruth	Yep. What else?
Child	To Hell.
Ruth	For ever and ever couldn't it? So there's got to be what? Something that stops it. And then what happens? If there's this big hole why does it keep on going down? Ruben gave us a big word. Something, when something's going down, its what? What's the word? Starts with a "P"? What do you do? Yes Ruben?

Child Pulling.

Children: Gravity.

(Ruth, Observation, 13. 10. 95)

Judith was reluctant to make too much of Ruth's incomplete knowledge of the topic for fear of discouraging her from teaching science. However Judith did ask whether Ruth felt the need to read beyond the resource materials in order to improve her own knowledge. Ruth said that she did not see the need at this level and felt her knowledge was adequate, but that she would read more if she were to teach older children.

Viewed from the perspective of the specialist subculture the generalist's knowledge of science will usually appear inadequate. Judith was aware that during observations of lessons she tended to focus on what she perceived to be science misconceptions and that initially, this prevented her from appreciating the lesson as a whole. When we went back and reflected on all that had occurred in such lessons, on most occasions, the misconception was of little importance. The lesson about gravity for example was designed to introduce the idea that the earth exerted a pull on all objects on or near its surface. The children were interested and showed, by the examples they suggested of the earth pulling on objects, that they were beginning to understand this concept. If a constructivist view of learning as continuing to build understanding is taken, the learning that occurred could be considered sufficient for the time being. The significance of the centre of the earth, which was not a lesson objective nor explained clearly in the teachers' notes, could wait for other occasions.

The status of science

Another contrast between the sub-cultures of generalist and specialist teachers is the relative importance of science in the curriculum at elementary school in comparison with its importance at secondary school or university. There is ample evidence that science in all three participants' schools had a low priority. Good examples of the low priority of science are also found in the comments made by both Jean and Ruth on the lack to time to teach science during their field experience.

> But this teacher on this prac. said to me, honestly there was no time (*to teach science*), we'll have to do a few science lessons and I said yes, I want to do a few science lessons. So we did one that was totally out of context. We were doing phonics, the ai sound so we thought we'd do snails. What she does she works with the sound every day and then does a craft that contains that sound, so we did snails. We made a snail out of paper and everything an then we thought why not do a science lesson and investigate the snail.
>
> (Ruth, Interview, 28. 12. 93)

> I felt science was put down there with phys. ed. I taught two lessons in the whole four weeks ...That was it. There was no time for science, every thing was language, language and maths but language took precedence.
>
> (Jean, Interview, 29. 11. 94)

The low priority of science was evident to in the way that science topics were usually chosen at Jean's school in 1995. She said that science was not a priority and was fitted into themes from other subjects. These themes are mostly based around language and were designed to suit the developmental needs of the children at the particular time of the year.

> Maths and language arts are still the priority things. . . It seems like they're the main structures in all the schools. ...science is kind of out there with social studies and if you can integrate it well and good and if you can't, well you know, you fit it in some time. ...that surprises me I think in a way because I think you can.... now that I've had a year out there, you could bring it in more I'm sure, if you really sat and looked at your planning, you could bring it in a lot more. So that's one thing I'll do next year is try and get all those subjects, health, science, social studies in more.
>
> (Jean, Interview,11. 12. 95)

At times when school life became particularly busy, science was often omitted. After Katie's success with the electricity lesson, Judith left the equipment kits at school for the other Year six teachers to use. Katie was enthusiastic about some of the extension activities in electricity and some printed materials were also left with her. However, no one else made use of the kits and Katie did not do any extension work. She explained by saying that all the teachers were very busy at the end of the year and that she herself had not taught science again after November 7, even though there was still a month of school term left.

As individuals, each of the participants was able to give priority to science in her own classroom. Ruth's companion Year two teacher complimented her on the amount of science she taught and introduced Ruth on a parent's evening as a science enthusiast. Jean believed that themes used in Year one during her first year as a teacher, often made it difficult to include science in the curriculum but that this need not be the case. In 1996 she decided to "do her own thing as far as science goes". The result of this was that Jean taught some new units including one on plant reproduction with

investigation and prediction as key elements. She was much happier that the children were involved in hands-on work and needed to really think about new concepts.

We were aware when Katie was interviewed at the end of 1996 that something interesting had happened in terms of her prioritising science in her elementary curriculum. She agreed to teach all the Year six science during 1996. This meant having three classes for science. We was initially concerned that this might restrict the amount of science taught as the other teachers had been reluctant to teach science in 1995 and might want to limit the amount of science taught. However, science was actually protected by the more important subjects, mathematics and English, that the other teachers took on rotation while Katie did the science. This meant that on the whole Katie had science in each class every week. We were surprised at her comment that she spent more time preparing science and reading about the topics she taught in 1996. She claimed that it was worth doing this now that science was three hours of her teaching time each week. Increasing the relative importance of science for one teacher in a year level seemed to us to be, in anthropological terms, a way of increasing Katie's investment in science teaching and thus increasing her interest in the game of science.

A reverse border crossing

When we reflect on the findings from this study in terms of the anthropological framework of border crossing between sub-cultures we find the crossing between the sub-culture of the generalist teacher and the specialist sub-cultures the most difficult. We believe that this sometimes seems to be the case because only the crossing of generalist teachers into the specialist world is considered. In other words generalists are urged to be more like specialists and to teach science in ways similar to those used by specialist teachers. For example generalists would benefit from a school-based system of science material management (Schoenberger & Russell, 1986) a special science classroom (Tilgner, 1990) and inservice courses to improve science concepts (Kruger, Palacio, & Summers, 1991).

Another way of considering the problem is to ask specialist teachers to make border crossings into the generalists' world. During the course of this study we began to see that reflecting on classroom observations had allowed us engage in anthropological learning. When Judith saw first hand the cramped classrooms she understood the appeal of science units that used teacher demonstration or had simple materials like the planisphere. She understood that when Ruth grew seeds there was not enough space in the classroom for each group of children to have their own pots, but Ruth allowed individual children to assist with planting and used class discussion to decide on situations for the pots and ways to control variables. Another example of our anthropological learning was a re-examination of our ideas about the science knowledge of generalist teachers. It is easy for specialists to find examples of missed opportunities for concept development or apparent misconceptions in the lessons of generalists. However, if these are seen in the context of the whole lesson they often seemed to us to be trivial. On occasions when we checked science teaching resources from which lessons were taken to see why a particular misconception might have occurred we were surprised to find that very little science background for teachers was included in some of the resources. The participants in this study seemed to use curriculum resources most often in preparing for lessons so that making links between children's activities and science knowledge could be an important feature of curriculum resource materials that would assist generalist teachers to make border crossings into the specialist sub-culture. However, anthropological learning in terms of better understanding of the generalist perspective was necessary before we could appreciate that the lesson notes were not supportive to non-specialists and that additional information might be helpful.

Conclusions

The use of an anthropological framework in this study allowed the difficulties experienced by elementary teachers in teaching science to be described as hazards encountered on borders between the existing sub-cultures of the participants and the sub-cultures they were required to enter in order to teach science. The findings reveal that beginning elementary teachers are engaged in crossing multiple sub-cultural borders in order to teach science. Like the preservice teachers described in the literature on elementary teacher education (Palmer, 1995; Soy, 1967; Young & Kellogg, 1993) the participants had arrived at university with a negative disposition toward science and the view that science as a subject for very intelligent people. Their high school experiences had not allowed them to cross the border into the science subculture and they had all experienced symbolic violence in their attempts to do so. Several features of science at university, hands-on activity, relatively slow pace, co-operative learning and the valuing of the learners initial ideas, allowed the teachers to make tentative crossings into the sub-culture of science and feel confident about their preparation to teach science. The participants were motivated by wanting to teach science in the elementary school in ways that would protect their own pupils from the difficulties, or border-crossing hazards, that they themselves had experienced.

The first year of teaching involves not just an extension or modification of beliefs and practices from teacher education but the development of a new perspective (Kyriacou, 1993). Research has indicated that for most beginning teachers this period is difficult and painful (Bullough, 1989; Lortie, 1975). In terms of the anthropological framework, the border crossing for most is hazardous. In fact the crossing can be so hazardous that researchers describe the early stages of teaching as a phase during which a new teacher concentrates on survival (Adams & Martray, 1981; Fuller, 1969; Hall & Jones, 1976; Pataniczek, 1978; Ryan, 1979). Some teachers negotiate this border crossing by making adaptations to their teaching behaviours and beliefs (Rust, 1994; Tabachnick, 1980; Zeichner & Tabachnick, 1981). Others are unable to make the crossing and leave the profession (Muller-Fohrbrodt, Cloetta, & Dann, 1978 in Veenman, 1984). Findings from this study indicate that the type of border crossing experienced by beginning teachers depends largely on the habitus (past experience and understanding) that they bring to their new occupation. Past experience can be both a help and a hindrance to border crossing. Two of the participants were assisted to enter the teaching subculture by their experience of parenting. The younger participant needed to adapt her habitus of the high achieving student to become an effective teacher. Field experience during preservice teaching can help to achieve realistic expectations of classrooms but evaluation during practice teaching may act as a hazard deterring real border crossing into the teaching subculture.

When researchers explored the reasons for the lack of science teaching in the elementary school, constraints or barriers to science teaching were identified (Johns, 1984). In terms of the anthropological perspective these constraints are inhibitors or hazards to border crossing. The participants in this study met similar hazards as they attempted to cross sub-cultural borders and teach elementary science. Like the teachers described in the research literature, the participants experienced a lack of interest in science and a lack of time to teach it in elementary schools (Fulton, Gates & Krockover, 1980; Grindrod, Klindworth, Martin & Tytler, 1991; Skamp, 1995) and struggled with the behaviour of children during hands-on investigative work (Abell & Roth, 1992; Grindrod, Klindworth, Martin & Tytler, 1991; Young, 1994). Findings from this study show that in the school situation the participating teachers were faced with the prospect of attempting to cross the border that separated them from the teaching profession, while at the same time crossing a different border that separated the elementary science classroom from the everyday elementary classroom. The hazards of the border crossing into the science classroom are thus magnified when they interact with the hazards of border crossing into teaching generally. This, together with the absence of a robust culture of science teaching in elementary schools, leaves beginners without tour guides or even travel agents in the form of more experienced science teachers and the necessity to negotiate a crossing with greatly increased hazards. The participants persisted with attempts to cross the borders into the science classroom. They seemed like the successful beginning elementary science teachers in the research literature (Abel & Roth, 1992; Fernandez & Ritchie, 1992; Tobin, Briscoe & Holman, 1990) to hold strong beliefs about and commitment to, the teaching strategies they were endeavoring to implement. The strength of these beliefs provided incentive to continue to attempt hazardous border crossings. The enthusiasm of elementary school children for science was another incentive for continuing teaching. These incentives or motivations to continue to overcome hazards or to endure symbolic violence, may be thought of as a form of *investment* (Bourdieu, 1990) in the game of science and seem as important in facilitating border crossing as finding ways of minimising hazards.

As researchers our perspective was from yet another sub-culture, that of the specialist science teacher. The use of the specialist teacher's perspective in evaluating elementary science classes was found to be problematic. Specialists who have researched the teaching of science by generalists have frequently found it to be deficient (Biddulph, Osborne & Freyberg, 1983; Rosier & Symington, 1990; Seddon, 1981). We believe that a more productive view is for specialists to see the generalist teaching world as a different but nevertheless valuable sub-culture and to explore ways in which border crossings between the two sub-cultures can be achieved for both groups of teachers. We have come to see that facilitating the teaching of elementary school science may involve taking a realistic view of the level of science knowledge actually needed by teachers and the space and resources really available for science in the elementary school. It may, for example, be necessary to make explicit links between science activity and science concepts for elementary teachers in curriculum materials they use. In university subjects it might be effective to use science activities and science learning spaces that more closely resemble the resources available to elementary teachers than is currently the case. The commitment of the participating teachers to implementing the elementary science curriculum seemed important in ensuring that individuals prioritised science teaching in their own classrooms. We believe that in the case of the participants this commitment was derived from relevant and positive experiences of science at university and children's enjoyment of the lessons taught in school. Thus it would be possible to counter the generally low status of elementary science by attempting to ensure that new graduates were confident and committed about science teaching. We are aware that the interest taken in participants' science teaching during this study had the potential to provide considerable incentive for persisting with science classes. It is impossible to estimate the extent of this influence but tempting to assume that new teachers benefit from the interest that others take in their work.

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